

taper towards the shells exterior. These spirally arranged blocks are usually associated with high concentrations of conchiolin.

The orientation of the spiral cones suggests that they can help inhibit chipping along the shell edge by certain predators. Aside from function, this is the first report of spirally oriented crossed-lamellar microstructures in molluscs. At this point we have not found similar microstructures in any other corbiculid bivalve (incl. *Polymesoda caroliniana* and the "purple" form of North American *Corbicula*).

NOTES ON THE HISTORIC AND PRESENT NAIAD FAUNA OF THE CANEY FORK RIVER, CENTRAL TENNESSEE.

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A survey of the naiad fauna of the Caney Fork River was conducted from August 1980 to August 1981 as part of planning for the Old Hickory Lake and Center Hill Lake projects. This work was performed for the Nashville District of the U.S. Army Corps of Engineers. Five locations were surveyed by first walking the banks and shoals looking for washed up shells. Shallow areas were searched with the aid of a water scope. In deeper water, naiads were located with a long-handled dredge. All relic and fossil shells were kept, cleaned, and sent to either Ohio State University or the University of Tennessee for identification or verification. Live naiads were identified and returned to the stream bottom.

A total of 36 species were represented in collections of relic and living naiads. The majority (28 species) were found only as relic or fossil shells from middens. The federally endangered species *Dromus dromas*, *Epioblasma florentina*, and *Pleurobema plenum* were collected as relic shells only. *Magnoniais nervosa*, *Amblema plicata*, *Fusconaia subrotunda*, *Elliptio crassidens*, *Elliptio dilatata*, *Potamilus alatus*, *Ligumia recta*, and *Lampsilis teres form teres* were collected alive.

Living naiads were collected infrequently no doubt due to their relatively low numbers in the Caney Fork River. The naiad fauna of the lower 27 miles of the river has not adapted to the combination of daily flow fluctuations (200 to 2000 cfs), cold water temperatures (hypolimnetic discharge), and nutrient poor water being released by the Center Hill Dam for peak electrical power generation. If one accepts 36 naiad species were once found alive in the river then a 78 percent reduction of the historic naiad fauna has occurred.

GAMETOGENESIS IN THREE HETEROGENERIC UNIONIDS (PELECYPODA: UNIONIDAE). **M. B. Kotrla**. Department of Biological Science, Florida State University, Tallahassee.

The seasonal gonadal cycles of *Anodonta imbecilis* (Anodontinae), *Elliptio icterina* (Pleurobeminae), and *Villosa villosa* (Lampsilinae) were compared histologically and histochemically. These species were selected because they are bradytictic, tachytictic, and horotictic respectively and because they belong to subfamilies which were distinguished

from one another on the basis of reproductive characters (Heard and Guckert, 1970, *Malacologia* 10:333-355). Specimens were collected monthly from a single site in Lake Talquin, Leon County, Florida for one year.

Neither the *E. icterina* specimens nor the *V. villosa* specimens are hermaphroditic. The female hermaphrodites of *A. imbecilis* have separate spermatogenic and oogenic acini. Four stages of gonad activity are observed: active gametogenic, ripe, spawned, and preparatory. The criteria by which these stages are distinguished are the degree of gamete maturation, the thickness and cell composition of the acinar epithelium, and the presence/absence of phagocytic cells in the acini. The time of year during which each stage occurs differs among species; within each species, spermatogenic and oogenic acini are not entirely synchronous.

Although sexual differences exist, there are no inter-specific differences in the morphology and histochemical reactions of acini at any given stage. During active gametogenesis, immature gametes (gonial cells, young oocytes, spermatocytes) are found at the periphery of the empty acinar lumina. Acini in the ripe stage are filled with mature gametes; few immature forms are present. After spawning, a few gametes remain in each acinus and the acinar epithelium is at its thinnest. During the preparatory stage the acinar epithelium thickens to its yearly maximum. Residual gametes are phagocytosed by amoeboid cells which migrate across the epithelium. In spermatogenic acini, there are multinucleated cells, termed sperm-morulae, which have been reported to give rise to sperm (Heard, 1975, *Malacologia* 15:81-103). The origin and fate of these structure have yet to be confirmed.

THE MECHANICS OF GLOCHIDIAL ATTACHMENT (MOLLUSCA: BIVALVIA: UNIONIDAE). **Michael A. Hoggarth**.

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Glochidia are third class levers in which the valves form the lever arms and the single adductor muscle produces the in force. In this study the dimensions of the in and out lever arms, and adductor muscle were found and the position of the adductor muscle located for 35 species of unionid glochidia. From these data and an analysis of the possible configurations of adductor muscle and valve dimensions, it was determined that a majority of the glochidia within the Anodontinae and the Lampsilinae take advantage of the mechanical benefits of their structure to maximize speed of glochidial valve adduction by possessing long out lever arms (*Anodonta*, *Anodontoides*, *Alasmidonta marginata*, *Lasmigona complanata*, *Lasmigona costata*, *Ptychobranchus*, *Obovaria*, *Leptodea*, *Potamilus*, *Villosa*, *Lampsilis* and some *Epioblasma*). Other glochidia have developed means to maximize force of glochidial valve adduction at the expense of speed, by the use of large diameter adductor muscles and short out lever arms (*Alasmidonta viridis*, *Lasmigona compressa*, *Strophitus undulatus undulatus* and *Strophitus undulatus tennesseensis*), or by the use of large diameter adductor muscles, long in lever arms and short out lever arms (*Pegias* and most *Epioblasma*). The Ambleminae were also

found to have evolved the mechanics for speed of glochidial valve adduction by the use of long out lever arms (*Tritogonia*, *Quadrula pustulosa pustulosa*, and *Amblema plicata plicata*). However, strength was maximized by the use of long lever arm alone (*Magnoniais nervosa*) or by the use of long in lever arms and short out lever arms (*Quadrula cylindrica cylindrica*, and *Fusconaia ebena*) although it is suggested that this is accompanied by disadvantage in the form of reduced gape. This study suggests that the mode of glochidial attachment, whether for speed or strength, has played a large part in glochidial morphology and has produced convergence in valve shape as well as in the location, orientation and size of the glochidial adductor muscle.

PRELIMINARY STUDIES OF DEGROWTH PHYSIOLOGIES IN THE FRESHWATER PULMONATE SNAILS, *HELISOMA TRIVOLVIS* AND *HELISOMA ANCEPS*.

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A number of studies have examined the physiology and tissue biomass changes in overwintering specimens of the freshwater pulmonate *Helisoma trivolvis*. These studies have included assessments of animals overwintering in the field and maintained under simulated winter conditions in the laboratory (Russell-Hunter and Eversole, 1976, *Comp. Biochem. Physiol.* 54A:447; Russell-Hunter et al., 1983 *Comp. Biochem. Physiol.* 74A:491; Russell-Hunter et al., 1984, *Ecology* 65:223). In both field and laboratory settings, there is good evidence for a tissue "degrowth" capacity in individual snails during overwintering conditions. Degrowth has been defined by Russell-Hunter and his colleagues as a decrease in unit mass of structural protein. When specimens of *Helisoma trivolvis* were held in a laboratory regime similar to winter conditions (8°C, no food), snails lost tissue biomass, including structural protein. Tissue degrowth was found in three of the four field populations studied by Russell-Hunter and his co-workers. The oxygen uptake and ammonia excretion rates also have been measured for individuals of *H. trivolvis* kept in laboratory degrowth conditions. These earlier studies provide some indication of the changing proportions of protein carbon and nonprotein carbon which are utilized as substrates in the degrowth physiology of *Helisoma trivolvis*.

Our work complements earlier studies by providing an age-specific experimental design and by including a related species, *Helisoma anceps*. We sampled a *H. trivolvis* population located in the Dawes Arboretum, near Newark, Ohio. Specimens of *H. anceps* were taken from a small spring-fed pond near Gambier, Ohio. Animals were collected in November, 1983, sorted by size and age, and maintained under simulated overwintering conditions in an environmental chamber set at 10°C, with a 14:10 light to dark cycle. Three hundred snails of each species were collected. The experimental design had three major categories of snails. One category was a pre-winter control group that was sacrificed shortly after collection. The other two categories were experimentals, snails that spent time in the laboratory under degrowth conditions. One of these categories was a fed group (offered an artificial food ration designed by Tashiro et al.,

1980, *Malacol. Rev.* 13:87), while snails in the other category were maintained without food. The "fed" and "unfed" groups were further divided into 35-day and 70-day subgroups, this designation representing the amount of time elapsing from the sacrifice of the controls to the sacrifice of a particular experimental subgroup. Finally, each experimental subgroup had old and young snails. The *H. trivolvis* population had one-, two-, and three-year-old animals (based on shell growth lines and size-frequency analysis). The *H. anceps* population had one- and two-year olds. We studied two- and three-year-old specimens of *H. trivolvis* and one- and two-year-old specimens of *H. anceps*. For each individual snail in all control and experimental groups and subgroups, we obtained oxygen consumptions, ammonia excretion, and urea excretion rates. These physiological measurements were made just prior to sacrifice of the animals. We also measured shell length, weighed shell CaCO₃, and determined shell-free tissue dry weights. There were no mortalities among the experimental animals.

There was evidence for degrowth in both species, regardless of whether or not food was available. The temperature regime of 10°C may be borderline for feeding activity. From our analysis of respiration rates in specimens of *H. trivolvis*, we conclude that rates in older animals (3-year-olds) decrease over a 70 day period of degrowth, while rates in younger animals (2-year-olds) increase. For *H. anceps*, respiratory rates of older snails (2-year-olds) increase during the degrowth period, but the rates of younger animals (1-year-olds) remained relatively constant during the degrowth regime.

The ammonia excretion patterns of *H. trivolvis* individuals were similar, regardless of age and trophic status. Rates were lower at 35 days, relative to both control values and rates measured at 70 days. In *H. anceps* individuals, there were age-specific and trophic-specific patterns of ammonia excretion. Younger fed animals had higher rates than older animals at the beginning of the experiment (controls) and at the 70-day sacrifice. The general patterns were a gradual increase in excretion rate through time for older animals, but a decrease (0 to 35 days) and then an increase (35 to 70 days) for young animals. In unfed specimens of *H. anceps*, young snails had higher rates of ammonia excretion at the beginning of the experiment and at the 35-day sacrifice.

The patterns of urea excretion were similar in unfed and fed, old and young specimens of *H. trivolvis*. There was a gradual increase in rates of urea excretion over the course of the 70 days of degrowth. For *H. anceps* individuals, urea excretion peaked at the 35-day sacrifice in both fed and unfed groups, but there was no clear age-specificity. Rates of unfed animals were greater than those fed during the experiment.

We conclude that there are clear species-specific and age-specific differences in the degrowth physiologies of *H. anceps* and *H. trivolvis*. Total nitrogen excreted (NH₃-N plus Urea-N) was fairly constant in specimens of *H. trivolvis*. For example, older unfed animals excreted roughly 7 to 10 ng N-hr⁻¹ during the course of the experiment, but the proportion of urea excreted increased steadily from negligible amounts